RSC-164
General Purpose Microcontroller Featuring Speech Recognition, Speech & Music Synthesis, Speaker Verification and Audio Record/Playback

Manufacturer
Sensory, Inc., 521 East Weddell Drive, Sunnyvale, CA 94089, USA. Tel. (408) 744-9000, fax (408) 744-1299. Internet: http://www.sensoryinc.com

Application example
Voice recognition with VoiceDirect, Elektor Electronics May 2000.

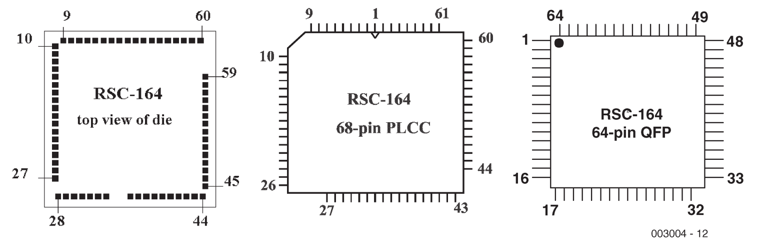
General description
The RSC-164, from the Interactive Speech™ family of products, is a low-cost microcontroller designed for use in consumer electronics. The RSC-164 combines an 8-bit microcontroller with high-quality speaker-independent and speaker-dependent speech recognition, speech synthesis, speaker verification, four-voice music synthesis, and voice record and playback. Products can use one or all of the RSC-164 features in a single application.
The RSC-164 employs a sophisticated neural network that learns to classify sound data. On-chip speech recognition algorithms reach an accuracy of greater than 96% for speaker-independent recognition and greater than 99% for speaker-dependent recognition. Sensory's neural network approach (patent pending) eliminates the need for expensive signal processing or extensive RAM storage.
The highly-integrated nature of the chip reduces external parts count. A complete system may be built with few additional parts other than a battery, speaker, microphone, and audio input support circuitry. Low power requirements make the RSC-164 an ideal solution for battery-powered and hand-held devices.

Features
Full Range of Speech Capabilities
- Speaker-independent speech recognition
- Speaker-dependent speech recognition
- High quality speech synthesis and sound effects
- Speaker verification
- Four-voice music synthesis
- Voice record & playback

Integrated Single-Chip Solution
- 4 MIPS 8-bit microcontroller
- On-chip A/D and D/A converters, digital filtering
- 32kHz clock for time keeping
- Internal 64kbytes ROM; 384 bytes RAM
- 16 general purpose I/O lines
- External memory bus: 16-bit Address, 8-bit Data
- On-chip output amplifier for direct speaker drive

Low Power Requirements
- 3.5 - 5.0V supply
- approx. 10mA operating

RSC-164 Instruction set
The instruction set for the RSC-164 has 52 instructions comprising 8 move, 7 rotate, 11 branch, 11 register arithmetic, 9 immediate arithmetic, and 6 miscellaneous instructions. All instructions are 3



Die-bond pad, PLCC and QFP pin drawings

Pin Descriptions

Name	*PLCC Pin/Die Pad*	*QFP*	*Pin Description*	*I/O*
AGND	64	52	Analog Ground. For noise reasons, analog and digital grounds should connect together only at the RSC-164.	-
A[15:0]	10-17, 20-27	1-8, 11-18	External Memory Address Bus	O
AIN0	63	51	Analog In, low gain. (range AGND to AVDD/2)	I
AIN1	62	50	Analog In, hi gain (8x input amplitude of AIN0, same range)	I
AVDD	67	55	Analog Voltage. For noise reasons, keep this supply independent of digital circuitry.	-
PWM0	65	53	Pulse Width Modulator Output0	O
DACOUT	60	48	Analog Output (unbuffered).	O
D[7:0]	2-9	57-64	External Data Bus	I/O
GND	1, 18, 33, 52	9, 22, 41, 56	Digital Ground, CPU core (pins 1 and 33) and I/O (pins 18 and 52)	-
PDN	57	NA	Power Down. Active high when powered down.	O
P1[7:0], P0[7:0]	35-42, 43-50	24-31, 32-39	General Purpose Port I/O. Pin P0.0 can act as an external interrupt input. All I/O pins can act as 'wake up' inputs.	I/O
-RDC	53	42	External Code Read Strobe	O
-RDD	55	44	External Data Read Strobe	O
-RESET	32	21	Reset	I
SH	61	49	Sample and Hold. Connect a 470 pF capacitor from here to AGND.	I
-TE1/PWM1	66	54	Test Mode or Pulse Width Modulator Output1 (multiplexed)	I or O
VDD	34, 68	23	Digital Supply Voltage (core)	-
VDDi	19, 51	10, 40	Digital Supply Voltage (I/O line)	-
-WRC	54	43	External Code Write Strobe	O
-WRD	56	45	External Data Write Strobe	O
-XMH	58	46	External Hi-memory enable (low active)	I
-XML	59	47	External Low-memory enable (low active)	I
XO1	30	19	Oscillator 1 output (high frequency)	O
XI1	31	20	Oscillator 1 input	I
XO2	29	NA	Oscillator 2 output (32768 Hz)	O
XI2	28	NA	Oscillator 2 input	I

bytes or fewer, and no instruction requires more than 8 clock cycles to execute.

General purpose I/O

The RSC-164 has 16 general purpose I/O pins (P0.0-P0.7, P1.0-P1.7). Each pin can be programmed as an input with weak pull-up (~200kΩ equivalent device); input with strong pull-up (~10kΩ equivalent device); input without pull-up, or as an output. This is accomplished by having 32 bits of configuration registers for the I/O pins (Port Control Register A and Port Control Register B for ports 0 and 1).

External memory

The RSC-164 includes an external memory interface that allows connection with memory devices for speaker-dependent speech recognition, audio record/playback, extended durations of speech and music synthesis, and enhanced product functionality. Separate data and address buses allow use of standard EPROMs, ROMs, SRAMs, and flash memory with little or no additional decoding. Provision of separate read and write signals for each external memory space further simplifies interfacing. The RSC-164 includes 8 data lines (D[7:0]) and 16 address lines (A[15:0]), along with associated control signals for interfacing to external memory. Using flash memory and EEPROM will require custom code development. The RSC-164 can connect serially through two I/O lines to a serial EEPROM for applications with low data storage requirements.

Oscillators

Two independent oscillators in the RSC-164 provide a high-frequency clock and a 32kHz timekeeping clock. The oscillator characteristics are as follows:

- Oscillator #1: Pins XI1, XO1
  14.32 MHz (3.5V-5.0V)
- Oscillator #2 Pins XI2 and XO2
  32768 Hz (3.5V-5.0V)

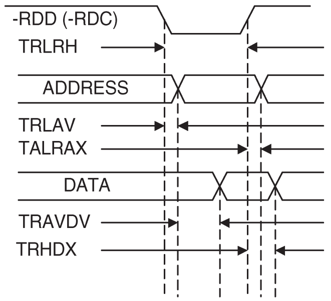
Oscillator #1 works with an external crystal, a ceramic resonator or LC. Use of Oscillator #2 requires a crystal for precision timing.

Clock

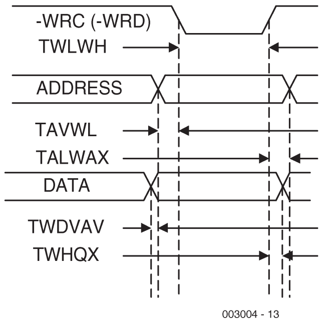
The RSC-164 uses a fully static core — the processor can be stopped (by removing the clock source) and restarted without causing a reset or losing contents of internal registers. Static operation is guaranteed from DC to 14.32 MHz.
Typically the processor clock runs from a 14.32 MHz crystal with no divisor and one wait state. This creates internal RAM cycles of 70 nsec duration and internal ROM or external cycles of 140 ns duration. Careful design of external decoding logic and close analysis of gate delays may allow operation with memories having access times as slow as 120 ns.

Timers/counters

The two independent oscillators of the RSC-164 provide counts to two internal timers. Each of the two timers consists of an 8-bit reload value register and an 8-bit up-counter.
The reload register is readable and writeable by the processor.



External read timing



External write timing

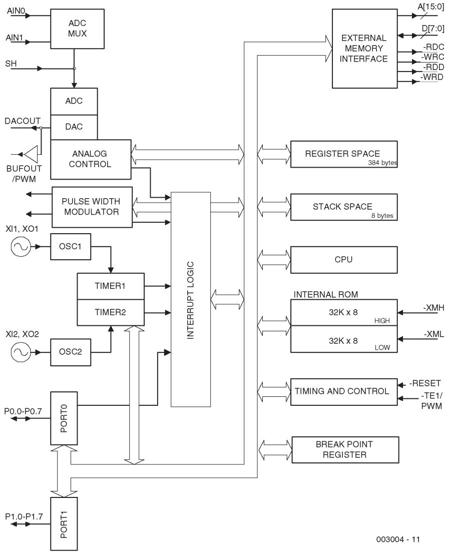
Interrupts

The RSC-164 allows for five interrupt sources, as selected by software. Each has its own mask bit and request bit in the IMR and IRQ registers respectively.
The following events can generate interrupts:

- Positive edge on Port 0, bit 0
- Overflow of Timer 1
- Overflow of Timer 2
- Sensory reserved functions
- Completion of PWM sample period

Analog output

The RSC-164 offers two separate options for analog output. The DAC (Digital to Analog Converter) output provides a general purpose 10-bit analog output that may be used for speech output (with the inclusion of an audio amplifier), or other purposes requiring an analog waveform. For speech applications that require driving a small speaker, the PWM (Pulse-Width Modulator) output can be used instead of the DAC output. The PWM output can directly drive a 32 ohm speaker.



RSC-164 Architecture

DC Characteristics (T0 = 0°C to +70°C, V_{dd} = 5V)

SYMBOL	PARAMETER	MIN	TYP	MAX	UNITS	TEST CONDITIONS
V_{IL}	Input Low Voltage	–0.1		0.75	V	
V_{IH}	Input High Voltage	2.5		Vdd+0.5	V	
V_{OL}	Output Low Voltage		0.3	0.5	V	I_{OL}= 4 mA
V_{OH}	Output High Voltage	4.0	4.3		V	I_{OL}= –4 mA
I_{IL}	Logical 0 Input Current					
I_{CC1}	Digital Supply Current		10		mA	Osc1 Freq=14.32 MHz, CPU clock divide by 1
I_{CC2}	Analog Supply Current		0.15		mA	Osc1 Freq=14.32 MHz, CPU clock divide by 1
I_{CC3}	Digital Supply Current, Standby					Power-down mode
I_{CC4}	Analog Supply Current, Standby					Power-down mode
Rpu	Pull-up resistance P0.0-P1.7	10	400	Hi-Z	kΩ	selected with software